IMPROVED PUMP DRIVE HEAD WITH INTEGRATED STUFFING BOX AND CLAMP

The invention relates to an improved pump drive with integrated stuffing box and clamp, i.e. a drive head for mounting at the top of a crude oil well pipe for operating the pump installed in the well, the pump being most commonly a positive displacement rotary design having a progressing helical cavity.

Known in the prior art are a number of different drives arranged to act on the ground surface end of the pump according to the well delivery rate. Thus, constant delivery rate wells mount electric motors connected drivingly to the pump shaft, the pump being as mentioned most commonly a rotary positive displacement type with a progressing helical cavity. Alternatively, a hydraulic motor is provided with a variable ratio hydraulic drive for tracking the well delivery rate up to steady state. The power transmission of the drive may include a gear or belt arrangement. In either case, however, the pump is to be coupled to the drive somewhere above the stuffing box, such that the interior of the well pipe, where the oil pressure is that created by the pump or is the pressure of the well itself, can be held isolated and the drive advantageously maintained at atmospheric pressure. Finally, under the pulling force applied to the drive shaft by a particular pump type, the transmission bearing block must withstand high axial thrust forces.

Known in the art are several ways of arranging the components of said head for easier servicing of parts that are more likely to undergo wear or failure, such as stuffing box leakage due to continual operation and the presence of silt deposits in the crude oil, or possible thrust bearing failure under the axial force exerted on the drive shaft by the pump. This involves periodical servicing and daily monitoring, usually by a technician.

During such servicing, the pump in the well should be shut down for the shortest possible time because, due to the mixed nature of the fluid being pumped it can easily become clogged, resulting in a costly well re-start procedure. Thus, quick replacement of parts is of vital importance to a short-duration stoppage of the well pump for service operations.

Known is, e.g. from US Patent Application 2001/0050168 A1, a pump drive head with an integrated stuffing box, wherein the stuffing box locates above the rotary drive and uses an internal standpipe attached to the coupling flange at the top of the well bore pipe. Thus, motion transmitted through the drive is used for rotating a tube mounted outside the stuffing box, since the coupling of the drive to the pump shaft is placed above the components of the head. The stuffing box, therefore, intervenes between the internal standpipe and the outside tube connecting the drive to the coupling of said tube to the pump inner shaft.

While by having the stuffing box placed on the top side of the head, a technician can reach it more conveniently, the stuffing box is difficult to check for tightness because the seal is mounted within a rotating part. The aforementioned patent application teaches ways of pressurizing the seals from a suitable hydraulic system to prevent leakage and spilling onto the ground. However, this involves significant complication over the conventional arrangement of the stuffing box below the drive head, whereby the extent of a failure can be checked visually by tapping the stuffing box at different levels.

In addition, the dual function of the drive main bearings/pump shaft thrust bearing invariably involves overhauling the whole drive, rather than just the thrust bearing as the component most subject to fail. Field disassembly of the drive requires more than an hour, compared to the 20 to 40 minute time limit for the well shutdown.

Finally, for the operation to be performed in less time, something has to be done to make the clamps on the underside of the wellhead a more practical design. To lock the pump driveshaft, a radial clamp means is closed around the shaft by means of two screws operated from outside. The aforementioned patent application illustrates a few designs for this means. The technician, before he can act on the head, locks the shaft in order to prevent it from dropping down the well; therefore, having to operate two screws may lead unskilled or careless personnel to torque one screw more than

the other and cause the shaft to bend or become damaged.

The prior art is open to considerable improvement in the way of providing the head with a pump drive which can obviate the above deficiencies and make the servicing procedures faster to complete and more effective in a reliable manner.

In the light of the foregoing, the underlying technical problem of the invention is to provide a pump drive head, the stuffing box and/or thrust bearing of which can be readily replaced without the drive having to be disassembled in the field, and while still using the conventional checking method of tapping at different levels. Another object is to allow for both standard and packing-type seals to be replaced the same way. Not least an object is to provide a clamp of simple construction to effectively hold the rotary shaft locked during servicing operations.

The above technical problem is solved by the invention providing an improved pump drive head having an integrated stuffing box and comprising: a power transmission coupled to the rotating pump driveshaft within a crude oil well; a stuffing box to retain the pressure; a thrust assembly adapted to take the tensile force exerted on said pump shaft; characterized in that said power transmission comprises a tube arranged to be rotated coaxially with the shaft and having at least two different diameters; that the rotary seals fit over the small outside diameter of the tube to establish fluid-tightness between said tube and the body of the stuffing box, the outside diameter of the seals being smaller than the large outside diameter of said tube; that the tube-to-shaft fit incorporates static seals; and that the rotating and static seals are adapted, by virtue of a retainer ring provided, to come away along with said tube and the component parts associated with the seals inside said stuffing box.

In a preferred embodiment, the tube, being rotated coaxially with the shaft, is connected with its bottom end axially to a sleeve for rotation therewith and to jointly define said large and small diameters, the small diameter locating inside the stuffing box and the tube and sleeve, once connected together, forming a unitary

piece.

In another preferred embodiment, a gasket is provided on the bottom end of said tube/sleeve for rotation therewith, the outside diameter of the gasket being a labyrinth pattern.

In another preferred embodiment, wherein the rotary seals are packing seals, an oil seal is provided downstream of the rotary seals and of the inlet hole for the liquid lubricant to the packing; the packing being mounted between said tube/rotating sleeve and the inner seat of the stuffing box.

In another embodiment, the packing is mounted on said rotating sleeve through at least one detent ring and a pre-load spring between the packing and said retainer ring.

In another embodiment, the packing is mounted around the small diameter of said tube/rotating sleeve and is held there by at least one axial retainer ring and a pre-load spring placed between the packing and the axial thrust assembly.

In another embodiment, the static seals are placed for reduced radial bulk in the joint region between said tube and said sleeve, and are compressed there to make a tight seal as said tube and sleeve are made fast together.

In another preferred embodiment, the static seals are placed for convenient replacement in the joint region between said tube and the shaft, and make a tight fit within the skirt of the top cover.

In another preferred embodiment, said tube is connected to the thrust assembly for rotation therewith by a rotating hub held in place by a guiding tighten-down means.

In another preferred embodiment, said hub is formed on its inside diameter with an axial slot for pulling out the connection tongue between said tube and the drive.

In another preferred embodiment, the packing pre-loading spring in the stuffing box is disposed inside a split casing to prevent overloading the spring when in the compressed state.

In another preferred embodiment, a ring spacer is provided in the stuffing box which is bored for communication with the liquid lubricant inlet hole and is formed with an annular seat for a lip-

type oil seal arranged to contact the diameter of said tube/sleeve.

In another embodiment, said bored ring spacer is formed with an axial middle ledge for insertion past the lip of an adjacent ring seal.

In another embodiment, a gasket with a labyrinth pattern on its inside diameter is keyed to the bottom end of the sleeve for rotation therewith.

In another preferred embodiment, a shaft locking clamp, advantageously placed within the body of the stuffing box, comprises a jaw pair, one pulls and one pushes, operated through a screw arranged to act with its end on one jaw and engaged in a threaded hole formed in the other jaw; said push and pull jaws being operated through a screw arranged to act with its end on the push jaw and engaged in a threaded hole formed in the pull jaw.

In another preferred embodiment, a clamp with self-centering jaws is associated with the body of the stuffing box, the jaws gripping the shaft in a wedge contact relationship of the outer surfaces of the jaws to the inner surface of the sliding body of the clamp under the action of the tighten-down screw; advantageously, this wedge contact is achieved by provision of a conical surface taper.

In a further preferred embodiment, the radial gripping movement of the self-centering jaws is guided by a prismatic fit of the clamp on the box or the cover; an elastic means is mounted between the two jaws to open them when the clamping action is released; advantageously, the shaft-gripping surfaces are semicircular about a center that is offset from the shaft centerline in a direction toward the opposite jaw.

One possible embodiment of the invention is shown by way of example in the accompanying ten drawing sheets, in which: Figure 1 is a longitudinal section view of the improved head according to the invention, showing the overall configurations of the stuffing box, drive (here a gear power transmission), thrust bearing, and clamp for locking the pump driveshaft; Figure 2 is a partial enlarged view limited to the rotating bearings of the drive, thrust bearing, and stuffing box; Figure 3 is a vertical cross-section view of the self-

centering clamp for locking the pump driveshaft; Figure 4 is a sectional plan view of the clamp of the preceding Figure; Figure 5 is a longitudinal section view of the improved head, with an unspecified drive, showing the overall configurations of the stuffing box, thrust bearing, and clamp for locking the pump driveshaft; Figure 6 is an enlarged detail view of the head shown in Figure 5; Figure 7 is a sectional view of the stuffing box highlighting the packing mount; Figure 8 is a sectional view of another embodiment of the improved head incorporating a modification of the stuffing box and the self-centering clamp; Figure 9 is an enlarged sectional view of the shaft power drive and the stuffing box; Figure 10 is an enlarged sectional view of the self-centering jaw clamp for the rotating shaft; and Figure 11 is a sectional plan view of the clamp shown in the preceding Figure, with one of the jaws being shown in section.

In Figure 1, the wellhead 1 is shown to include the drive 2 with gears 3, 4 that are driven by the motor M, the gear 4 being keyed to a rotating tube 5 connected upwardly to the thrust assembly 6 and, through the conventional coupling 7, to the rotating driveshaft 8 of the pump down the well bore. Also, the stuffing box 9 is shown beneath the drive 2 and as being advantageously integrated here to the self-centering clamp 10 with jaws for locking the shaft 8.

Figure 2 shows in greater detail the main bearings 11 for the gear wheel 4 on the housing 12 of the drive 2. The rotating tube 5 is keyed to the gear wheel 4 by the tongue 13 and extends coaxially within the gear wheel 4. The bottom end 14 of the tube 5 is threaded at 15 for engagement with the rotating sleeve 16 of the stuffing box. Static ring seals 17 are held compressed between said end 14 and the sleeve 16, these being the parts that would bear on the rings during rotation. The rotating sleeve 16 of the stuffing box carries the axial thrust bearing 18 arranged, inside the body 19 of said box, to take the axial load from the well pressure acting on the seals 20. Engaged threadably with the bottom end 21 of said rotating sleeve 16 is the retainer ring 22 arranged to retain said seals and used for pulling them off, the seals being shown held

apart by spacers 23 that abut against said thrust bearing 18. A rubber gasket 24 is connected to the retainer ring 22 which is formed with a peripheral labyrinth pattern 25 on its outside diameter to catch as much as possible of the solids trapped in the pumped fluid. A radial tapping hole 26 is formed above the gasket 24 and at each oil seal 20 for use, when required, to check the respective upstream seal for leakage under the well pressure.

Also in Figure 2, said tube 5 is shown connected rotatably to the hub 27 of the thrust bearing, to which it is fastened together with the top cover 28 by the screws 29. This hub can rotate under the bell 30 covering the bearing 31 of the thrust assembly 6, and has an upper oil seal 32. This bell is fastened to the housing 12 of the drive 2 by screws 33. Said hub 27 is formed with an axial slot 34 on its inside diameter to allow the tongue 13 to be pulled away without the thrust assembly 6, i.e. the hub 27, bell 30 and bearing 31 having to be disassembled.

Figure 3 shows the pull and push jaws 35 and 36 around the outside diameter of the shaft 8. For enhanced grip, the contact areas are knurled horizontally as at 37. The jaw pair are closed by the outside-operated screw 38, which screw is provided with a seal 39 around its stem 40 to stop leakage of pressurized fluid. The female threadway is formed on the body of the pull jaw 35, and the end of the screw 41 acts on the push jaw 36. In Figure 3, the clamp 10 is shown open, and is shown closed in Figure 4. For guiding and elastic bias purposes, at least two pins 43 and two springs 44 are placed between the pull jaw 35 and the cover 42, which are effective to keep the jaws from turning and bias them to the open position.

Shown in Figure 5 is the head for the power transmission 45 to the shaft of the pump 8 of a crude oil well, when the head is constructed other than from gears, e.g. comprises a pulley (not shown) keyed to the tube 46 by the tongue 47 to rotate with the tube. The thrust assembly 6 is provided with a hub 48, similar to the hub 27 described above but formed with no axial slot. This thrust assembly, having to take radial forces on said tube 46 as well, additionally includes a radial bearing 49 and the sleeve 16 of

the stuffing box 9. Figure 6 shows in further detail the stuffing box with the oil seals 20 and intervening rings 23, and the static seals 17 held tight on said shaft 8 by the end 14 of the tube 46. It can be seen that the hub 48 guides the sleeve 16 of the stuffing box, and above this, said tube 46. In this it differs from the embodiment shown in Figure 2, wherein the sleeve 16 of the stuffing box and the tube 5 are guided on the hub of the gear wheel 4.

Furthermore, Figure 7 shows the bottom end 21 of said rotating sleeve 16 engaged threadably with the ring 22 to retain said packing 50, itself located between said sleeve and the inner seat 51 of the stuffing box 9. The packing is retained on said sleeve by the retainer ring 22, the detent rings 52 and spring 53 against said axial thrust bearing 18. A bored ring spacer 54 and an oil seal 55 are provided between the packing 50 and said bearing 18. Said inner seat 51 has a shoulder 56 for abutment by the ring 52 in the assembled state. The spring 53 is to pre-load the packing 50, and in the assembled state, the ring 22 will be held spaced apart from the bottom detent ring 52. The tapping holes 57, where provided, are covered by the packing 50. The hole 58 is to admit lube oil to the inside diameter of the packing as this is sliding across the outer surface of said rotating sleeve 16. On possible collapsing failure of the packing 50, the well fluid would rise above the bearing 18 and overflow through the vent hole 59 at atmospheric pressure.

Another embodiment of the head is illustrated by Figures 8 to 11. In Figure 8, there is shown the integrated stuffing box 60, where a sleeve 61 is rotated rigidly with the shaft 8 in rubbing relationship to the packing 50. This sleeve extends coaxially with and is firmly coupled in sealed relationship to the tube 62 that transfers the motion from the gear 4 to the coupling 7 via the skirt 63 of the cover 28. The static seals 64 are placed between the cover skirt and the shaft 8, so that the seals 64 can be readily pulled off by first uncoupling the coupling 7 and removing the cover 28 with the skirt 63. Furthermore, the clamp 65 is shown located beneath said integrated stuffing box with its self-centering jaws 66 closed by actuation of just the lead screw 67 and by effect of the

conical fit 68 provided between the jaws and the sliding body 69.

Shown in Figure 9 is the body 12 of the head 1, whose upper portion 70 receives the thrust assembly 6 mounted under the bell 71, the latter being fastened by screws 72. The body 73 of the stuffing box 60 is an integral part of the drive housing 12 and is formed with two radial holes, of which the lower one 74 is located upstream of the packing 50 same as the lowermost one of the holes 57, and the upper one 75 same as hole 58, for supplying clean lube oil to the rotary packing-type seal 50 acting on the outside diameter of the sleeve 61. The gasket 76 with labyrinth 77, in static contact with the shaft 8, is keyed to the bottom end of the sleeve 61 for rotation therewith. Said bottom end of the sleeve also carries the axial retainer ring 78 for pulling off the internal components of the stuffing box 60. An axial retainer ring 79, being larger than ring 78, is mounted between the lowermost packing 50 and an axial ledge 80 on the body 73. Next to said packing is a casing split into two halves 81 and 82 that are spaced apart to enclose the packing pre-load spring 83. The casing contacts with its top portion the ring 84, which ring is drilled radially to provide a passage for the pressurized lube oil from the hole 75. The bottom portion of this ring is formed with an inner seat 85 receiving a rotary lip seal 86, the top portion of the ring being formed with a middle, axially extending ledge 87 for insertion between the outer metal shell and the outer/inner lip of a seal ring 88 on the surface of said rotating sleeve 61. This middle ledge 87 is to transfer a possible axial thrust load directly to the axial thrust bearing 18. Last, an isolating ring 89, provided for the thrust bearing 31, fits over the outer diameters of the hub 27 and the hub of gear 11.

Figures 10 and 11, illustrating another embodiment of the self-centering clamp 65 for locking the shaft 8, show recesses 90 provided in the body 69 for the shaft 8 to go through during the clamp-down operation. Each said self-centering jaw 66 is provided with a pin 91 for guided movement in the slot 92 formed in the cover 93 of the clamp casing 94. Each jaw has a prismatic guide 95 that lies normal to the direction of the jaw radial gripping movement,

the guide tapering along the radial direction of the shaft 8. The prismatic guide 95 fits for radial sliding movement in a circular groove 96 cut in said cover 93, with the jaw being guided by said pins 91. Two springs 97 are received in sockets along a parallel direction to the clamping direction to bias the jaws 66 to the open position upon removal of the clamp-down force. A socket 98 is provided in the area of the screw 67 on the body 69 to allow the screw head through, and rotation-preventing pins 99 ensure an orientated setting of the body 69 within the casing 94. The shaft-gripping surfaces 100 are semicircular about a center which is offset toward the opposite jaw with respect to the centerline of shaft 8, and are slightly roughened with circular cross-section knurled formations.

The wellhead and drive disassembling/re-assembling for servicing is effected, upon the shaft 8 being stopped from rotating, by operating the screw 38 to close the clamp 10 such that its jaws 35, 36 will grip the shaft; the jaws self-centering themselves around the shaft without damaging it. Once the shaft is clamped down and the well pressure exhausted, a conventional device is used for loosening the coupling 7 and releasing the connection between the shaft 8 and the rotating tube 5 or 46. By removing the screws 29 and cover 28, the sleeve 16, static seals 17 and oil seals 20 of the stuffing box 9 can be slipped off for quick replacement. In the embodiment of Figure 2, the tongue 13 would not interfere with removal of the tube 5 because of the slot 34 provided in the hub 27. Replacement of the tube assembly 5 or 46, sleeve 16 with the static seals 17, bearing 18, rotary seals 20, oil seals or packing, retainer ring 22, and gasket 24 is quickly effected for a minimum of well shutdown. Assembly would proceed in the reverse order.

To also take down the thrust assembly 6, by loosening the screws 33 the thrust bearing 32 is released. Where both the stuffing box and thrust assembly are to be replaced, by merely loosening the screws 33 the thrust assembly 6 and stuffing box assembly can be removed in a single, readily performed operation. In this respect, the embodiments of Figure 2 and Figure 6 would be dealt with in a

slightly different manner from each other, namely the gear transmission 2 would remain connected to the body 19 of the stuffing box 9, as would the respective bearings 11, and the bearing 49 removed together with the thrust assembly 6 and the inner parts of the stuffing box 9.

Finally, the holes 26, in addition to being useful to tap off leakage past the oil seal 20 or the gasket 24 located upstream, may be used to introduce fluid, advantageously oil, under a pressure in order to enhance the sealing action of the affected oil seal 20, the pressure being propagated to the next oil seals in the direction toward the thrust bearing 18.

When the packing 50 is employed, the ring 22 would be retaining the packing 50 and detent rings 52 for assembling. For disassembling, the ring 22, by acting against said detent rings 52 and the fully compressed spring 53, would urge the compressed packing against the inner wall 51 of the box 9 and loosen it, thus allowing it to be removed as a whole.

In the embodiment of Figures 8 and 9, the stuffing box operates as explained here below. Upon assembly, the packing 50 would be forced by the spring 83 against the axial retainer ring 79 and ledge 80; the packing being compressed between the outside diameter of the rotating sleeve 61 and the bore in the body 73. The sleeve turns together with the shaft 8 and the gasket 76 with labyrinth 77 to stop slime in the crude oil being lifted from reaching, under the pressure, the static seals 64 between the shaft 8 and the sleeve 63 at the top end of the head. The additional axial retainer ring 78 is utilized as the packing and internal components of the stuffing box 60 are taken out; it functions as an axial retainer to prevent components from coming off. The split casing 81, 82 allows the spring to preload the packing at the same time as it prevents overloading the spring 83 should the backpressure of the clean oil outflowing from the hole 75 vanish while in operation. In the last-mentioned case, the axial thrust would be transferred from the packing 5 to the casing, and thence directly to the ring 84; from this ring, it would be further propagated to the axial thrust

bearing 18 via the axial middle ledge 87. Thus, the thrust force would leave the lip seal 86 unaffected and free to cling firmly; nor would it affect the seal ring 88, because the axial middle ledge 87 transfers the thrust directly to that portion of the seal ring which is strongest in the axial direction. The ring 88 stops the clean lube oil from entering the upper chamber outside the stuffing box 60, and the lip seal or oil seal 86 allows the clean lube oil from the hole 75 to flow through, but prevents clean oil and crude oil from flowing back to the bored ring 84. The lip or oil seal 86 would not wear out, because in general, well pressure only makes itself felt while the shaft is held stationary. In operation, the clean lube oil to the packing is admitted through the hole 75 and distributed between said seal ring 88 and the packing 50 to also fill the annular chamber inside the split casing 81, 82. The lube oil pressure is maintained above the well pressure to prevent dripping past the packing to the head, so that the dripping is conveyed into the well and the contact between the packing and the sleeve 61 can be kept in a suitable condition for proper performance and a long life.

For servicing, the hole 74 is used for draining the stuffing box 60 before disassembly, thereby avoiding undesirable splashes as may foul the thrust bearing 31 and besmear the operator. In addition, said hole allows the stuffing box 60 to be flushed clean with its internal components and the packing in place before the well is re-started.

The shaft locking clamp 65 with its self-centering jaws 66 is operated by first tightening down the screw 67 to urge the clamp body 69 in a radial direction of the shaft 8 against the jaws 66 and cause the latter to close around the shaft 8 along normal directions to the body direction of displacement. The contact between the body and the jaws occurs across the inside taper 68 of the body and the mating outside taper of the jaws 66. The jaws will be guided in their movement toward each other by the taper 68, the prismatic guide 95, and the pins 91 in the slot 92. At the end of the clamp-down step, the springs 97 will move the jaws 66 away as the body 69

is pushed back by turning the screw 67 in the opposite direction.

Advantages of this invention are that: by having the stuffing box 9 mounted below the thrust assembly 6 and the drive components, full operational control of the rotating seals 20 or 50 and the gasket 24 is achieved; by having the thrust assembly placed at the top, with the inner components of the stuffing box 9 removable through the top, replacement is quickly effected with only a very short well shutdown; the operator can thus maintain a comprehensive stock of spare parts that may include the thrust assembly 6, and directly replace any worn out or failed items in a wellhead.

In practicing the invention, the materials used, the dimensions and construction details may be other than those described hereinabove, yet be technical equivalents thereof, without departing from the juridical domain of the present invention. The tube 62/sleeve 61 combination could be manufactured as a unit, although this would entail a more complicated construction and be cost-intensive.

Thus, the clamp 10 or analogously the clamp 65 could be provided, although less conveniently, as an independent unit rather than as an attachment to the body 19 of the stuffing box 9.

An unrelated construction, as provided by the invention, of the stuffing box 9 to the thrust assembly 6, although feasible, would be less convenient. In fact, the more readily damaged items in use would be the seals between rotating parts, oil seals or packings, thrust bearing 31, and static seals 17 and 64. A separate construction, although feasible, would impair simultaneous quick replaceability of the parts when damaged, the rotating seals 20 or 50, the thrust assembly 6, and the gasket 24. On the other hand, the shaft locking clamp 10 or 65 could be a separate construction, unlike that shown in Figures 1, 5 and 8 having the clamp integral with the body of the stuffing box.